PATENT SPECIFICATION

742,494

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COMPLETE SPECIFICATION

Improvements relating to Electro-Magnetic Control Means

I, HARRY HOWE, a British Subject, of Oakfield, 13 Carlton Road, Hale, Cheshire, do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to improvements in or modifications of the electro-magnetic control means according to specification No. 4766/53 (Serial No. 742,487).

Specification No. 4766/53 (Serial No. 742487) describes and claims electro-magnetic devices for use on single or multi-phase A.C. circuits, having main windings for connection to input and output circuits, carried by two main magnetic cores each of which is divided into two physically separate subsidiary magnetic core elements, the subsidiary elements of at least one main core being provided with windings independent of the main primary windings of the device whereby they may be excited for the purpose of reducing or suppressing the main magnetic flux in the main magnetic core of which the subsidiary elements are parts, and diverting it to the other main magnetic core.

According to the present invention the two subsidiary core elements constituting each main magnetic core are dimensioned to carry equal proportions of flux and the two elements constituting each magnetic circuit are energised by a primary winding divided between both elements at least one pair of elements being provided with a single exciting winding collectively embracing them, the fluxes in each element due to the primary winding being arranged to link in opposite directions with the said exciting winding so that the exciting winding is non-inductive with respect to the said primary flux and no voltage is induced in it thereby so that the exciting winding can be energised from any separate source of supply for the purpose of reducing or suppressing the main magnetic flux in the main magnetic core of which the subsidiary elements are parts, and diverting it to the other main magnetic core or vice-versa.

As in the arrangement in Specification No. 4766/53 (Serial No. 742,487) divided main cores are employed but instead of the primary excitation being applied to the two parts of a divided core by a single primary winding, and auxiliary excitation being applied in one element in the same direction as the primary excitation and in the other element in the opposite direction to the primary excitation, the arrangement is now reversed and the two elements of a main core are individually energised by separate primary winding sections, and the auxiliary excitation is applied by a single exciting winding embracing the two elements the primary windings being arranged so that the inductive effects they produce in the exciting winding or windings neutralise one another.

Secondary windings are provided on the individual cores where required and are closely coupled to the appropriate primary winding, and whilst the latter magnetises the elements of a magnetic core in mutually opposite directions, the individual secondaries coupled to the individual primary windings are connected cumulatively in series or parallel, as desired.

The invention employs two main magnetic cores of the closed ring type of rectangular or circular form constructed of stacked laminations of magnetic material or spirally wound strip. Each core comprises two closed ring type elements adapted to be energised in mutually opposite directions by a separate primary windings on each. The individual main windings and the subsidiary windings may be of the conventional type or of the toroidal type depending on the types of core employed.

Referring to the accompanying drawings:—

Figures 1 to 4 show various arrangements of the magnetic circuits of the device employing frame or ring type cores.

In the various arrangements shown the primary windings associated with a particular main core are shown connected in series but may, if desired, be connected in parallel. The

former arrangement is, however, to be preferred since it provides more stable results by ensuring an even distribution of flux in the two core elements. Where primary windings associated with a particular core are connected in parallel, A.C. excitation is not suitable, since the paralleling connections provide the equivalent of a short circuited turn when A.C. excitation is applied. The arrangement is however quite satisfactory if D.C. or rectified A.C. excitation is employed.

In the examples shown the secondary windings have been omitted for the sake of clarity and will be shown in detail later.

Figure 1 shows two cores F and G constituting a complete device. One of the subsidiary core elements of the pair F consists of two limbs F1 and F2A whilst the other comprises limbs F2B and F3. Likewise one of the elements of the pair G consists of two limbs G1 and G2A whilst the other comprises limbs G2B and G3. The limbs F1 and F3 are energised by primary windings P1 and P2 respectively, these being connected in series to energise the said limbs oppositely whilst the limbs G1 and G3 are energised by primary windings P3 and P4 respectively, these being also connected oppositely in series. The two groups of series connected windings are then connected in series to the source of supply L1—L2. The two portions of core F each become energised in a clockwise direction during a particular half cycle as shown by the arrows and the same state of affairs will obtain in the two portions of core G. It will thus be noted that in the divided core F the primary flux passes through the limbs F2A and F2B in opposite directions as shown by the arrows and therefore through an exciting winding H1 arranged to embrace the limbs F2A and F2B which is free from inductive effects due to the combined primary fluxes and may thus be independently energised from a D.C.—A.C. or rectified or partly rectified source of supply at any chosen voltage or current. The same state of affairs will exist in the divided core G, in which the primary flux circulates in the same manner as shown by the arrows in the divided core F—the two portions of core G being provided with a subsidiary excitation winding H3 embracing the limbs G2A and G2B. When the supplementary excitation winding H3 is energised it will produce a field in the two limbs in the same direction respectively as will also winding H1 in the two limbs F2A and F2B on core F, the directions of the subsidiary excitation in both instances being as shown by the arrows in core G. If the winding H1 on the core F is excited to saturation of the core the primary windings P1 and P2 will be unable to create any flux in the already saturated cores and hence there will be no voltage across them, but since the group of primary windings P3, P4 on the core G are in series with them the whole of the supply voltage will be transferred to the windings P3, P4; thus the whole of the primary flux will be concentrated in the core G and none in the core F. If the winding H3 is energised and the winding H1 de-energised the whole of the primary flux is transferred from the core G to the core F.

The arrangement shown in Figure 1 is mainly diagrammatic and a practical form is shown in Figure 2 with further variations as shown in Figure 3 where two pairs of frames are shown vertically stacked whilst Figure 4 shows each of the two concentric frames constituting each pair of cores vertically stacked. The frames, may, of course equally well be of circular instead of rectangular form—in which case toroidal windings may be distributed throughout the whole circumference, the various separate windings being wound over each other—thus ensuring the close coupling desirable for obtaining stability of output voltage under loaded conditions. In Figures 2—4 the direction of the main primary flux is shown by the full line arrows, whilst the direction of the subsidiary excitation is shown by the dotted arrows.

Figures 5 to 7 show diagrammatically a number of arrangements of the device in which the secondary windings have been included in varying combinations to suit different applications or requirements. The primary and subsidiary excitation windings are also shown and the full operation of the device will be described in reference to the various diagrams.

Figure 5 shows the device based on Figure 1 having a main core F comprising parts F1—F2A and F2B—F3, and a main core G comprising parts G1—G2A and G2B—G3. The four core parts are embraced by separate primary windings P1, P2, P3 and P4. The primary windings P1 and P2 are connected in series providing main magnetisation in opposite directions in the two parts comprising core F as shown by the arrows and in like manner primary windings P3, P4 provide main magnetisation in mutually opposite directions in the two parts comprising core G, and the two sets of primary windings are connected in series across the source of supply L1, L2. The core parts diagrammatically shown are intended to denote closed magnetic rings. The subsidiary excitation winding H1 collectively embraces the two parts F1—F2A and F2B—F3 of core F, whilst subsidiary excitation winding H3 embraces the two parts G1—G2A and G2B—G3 of core G. Secondary windings S1 and S2 embrace the two parts of core F and are connected cumulatively in series. The subsidiary excitation windings H1 and H3 are connected in series across a source of supply—in this case the A.C. supply system L1, L2, the centre point of which is connected to a changeover switch J connected across the line so that either of

the windings H1 or H3 may be energised through it. With the switch in the position shown, the subsidiary winding H1 becomes energised from the supply line L1 through the winding H1 and the lower switch blade on the switch J to the supply line L2, whilst the subsidiary winding H3 is short circuited. The winding H1 energises the two parts of the core F which it collectively embraces and saturates them so that the primary windings P1 and P2 are unable to set up any flux therein and the voltage across them is practically nil as also is the voltage across the secondary windings S1, S2 at the output terminals V, Z. The disappearance of the voltage across the primary windings P1, P2 is accompanied by a corresponding increase of voltage across the primary windings P3, P4 to practically the line voltage which amounts to a complete transference of flux from the core F to the core G and the output voltage across V, Z becomes zero. If now the switch J is changed over to the opposite position the reverse state of affairs obtains, and the subsidiary excitation winding H3 on the core G becomes energised, saturating the two parts of the core G, thus causing the voltage across the primary windings P3, P4 to decrease to zero and that across the windings P1, P2 to increase to approximately line volts. As a result of this, the secondary windings S1 and S2 acquire maximum induced voltage and full output voltage is available across terminals V, Z. Thus by opening and closing the switch an output voltage across the device may be established or dis-established without breaking any of the main circuit conductors. The direction of fluxes in the various parts of the circuit is indicated by the arrows.

Figure 6 shows two cores F and G energised by primary windings P1, P2, P3 and P4, as in Figure 5, but the subsidiary excitation is applied to the core G only through the winding H3 collectively embracing the two parts of the core G. The latter winding is connected from the line L2 through a normally open switch J1 to the line L1. Secondary windings S1—S2 individually embrace the two parts constituting the core F and are connected cumulatively in series as are secondary windings S3 and S4 on the two parts comprising the core G. The groups of secondary windings on the core F are connected oppositely in series with the group on the core G. With the switch J1 open and the primary windings P1, P2, P3 and P4 energised from supply line L1 and L2, each of the cores F and G is energised at half voltage due to the two groups of primary windings being connected in series. The secondary windings on the cores F and G, being connected oppositely in series, thus produce zero output volts, half the normal voltage existing across the windings on each core. On closing the switch J1 subsidiary excitation is applied by winding H3 from supply lines L1, L2 which saturates the whole of the core G and drives out the flux into the core F, so that the voltage across the secondary windings S3—S4 on the core G is reduced to zero due to the voltage across the primary windings P3, P4 being reduced to zero, whilst the secondary voltage from the combined secondary windings S1 and S2 on the core F increases to maximum following a rise in the voltage across the primary windings P1, P2 on the core F due to the shifting of the flux from the core G to the core F. A maximum output voltage is therefore, available across the output terminals V, Z. The switch J1 also provides a remote means of establishing or disestablishing an output voltage.

Figure 7 shows an arrangement where the primary windings P1, P2, P3 and P4 are connected as in Figure 5, whilst the subsidiary excitation windings H1 and H2 individually embrace the two parts of the core F and are connected cumulatively in series and the corresponding windings H3, H4 embrace the core G in similar fashion, the two groups of windings being connected through a switch J to the supply lines L1, L2 in similar manner to that already described in connection with Figure 5. Secondary windings S1 and S2 individually embrace the two parts of the core F and are connected cumulatively in series, one end of the combined windings being connected to the supply line L1 in auto-transformer fashion so that it provides a subtractive voltage in respect to the voltage of the supply system and provides a zero output voltage overall between the end of the secondary winding S2 and the supply line L2, connected to the output terminals V, Z, with the switch in the position shown. In these circumstances the subsidiary excitation windings H3, H4 are excited from the supply lines L1, L2 and saturate the two parts of the core G driving the flux from the latter into the core F whereupon the primary volts disappear from the windings P3, P4 on the core G and the voltage across the windings P1, P2 on the two parts of the core F becomes correspondingly increased, so that maximum induced voltage across the secondary windings S1, S2 individually embracing the two parts of core F is obtained, and as this voltage is in opposition to the line voltage to which they are connected, the output voltage across terminals V, Z is zero. On changing the switch J to the opposite position the reverse action takes place, the subsidiary excitation windings H1—H2 now being connected across supply lines L1, L2 and saturating the two branches of the core F, thereby driving out the flux in its entirety to the core G. This is accompanied by the primary voltage across the windings P1 and P2 decreasing to zero and the secondary voltage across the windings S1 and S2 on the core F likewise becoming

reduced to zero, the net result of which is that due to the disappearance of the subtractive voltage from the secondary windings an output voltage approximately equal to the line volts and supplied from the source is available across terminals V—Z. In this manner the switch J may be used to establish and disestablish an output voltage across terminals V—Z without interrupting the main conductors.

In this application it will be appreciated that the device is normally called upon to provide an overall zero output voltage where, of course, the load is also of practically zero value. When the output voltage is established the device ceases to provide any subtractive voltage since the load is supplied from the supply system for which reasons the device needs only to be physically small for such a purpose.

An alternative arrangement of the device of Figure 7, comprises the use of a potentiometer regulator or equivalent device, as shown at K, which is connected across the supply system L1, L2 with the regulating arm connected to the central point of the series connection joining together the two groups of subsidiary exciting windings. By means of this regulator the excitation of the parts of one core may be increased whilst that on the other core is correspondingly decreased since it is an essential condition for stability under fluctuating load conditions when adapting the device for regulating purposes to ensure a constant total value of subsidiary excitation between the two cores at any particular supply voltage.

In the foregoing examples the subsidiary excitation has been taken direct from the A.C. source of supply but is not restricted to such. Provided the subsidiary windings are free from any inductive effects from the main magnetisation, as they should be, any kind of current D.C., A.C., or rectified A.C. or any combination of these may be employed and at any chosen voltage or current values, provided that the individual primary windings on a core are connected in series. If they are parallel connected the subsidiary excitation current should be unidirectional.

Single purpose windings for subsidiary excitation have been shown in the various illustrations but additional excitation windings may be applied—using different kinds of exciting currents if desired, for feed back, bias, and compensation purposes for producing particular output features or characteristics as will be understood by those familiar with these techniques.

The arrangements described in the foregoing have been confined to single phase supply systems but any of the arrangements may equally well be adapted for operation on three-phase systems by using three units or devices connected in "star" or "delta" in the manner shown in Specification No. 4766/53 (Serial No. 742,487).

In view of the innumerable possible variations of connection arrangements and combinations comprising the invention the foregoing examples are only intended to be typical.

What we claim is:—

1. An electro-magnetic device for use in single or multi-phase A.C. circuits as claimed in claim 1 of Specification No. 4766/53 in which the two separate subsidiary core elements constituting each main magnetic core are dimensioned to carry equal proportions of flux and the two elements constituting each magnetic circuit are energised by a primary winding divided between both elements, at least one pair of elements being provided with a single exciting winding collectively embracing them; the fluxes in each element due to the primary winding being arranged to link in opposite directions with the said exciting winding so that the exciting winding is non-inductive with respect to the said primary winding and no voltage is induced in it thereby so that the exciting winding can be energised from any separate source of supply for the purpose of reducing or suppressing the main magnetic flux in the main magnetic core of which the subsidiary elements are parts, and diverting it to the other main magnetic core or vice-versa.

2. A device as claimed in claim 1, in which the divided primary winding on one of the two main magnetic cores is connected in series with the divided primary winding on the other main core, enabling the potential distribution between the two windings on the two cores to be varied by the subsidiary excitation by which the main magnetic flux is diverted wholly or partially from one core to the other.

3. A device as claimed in claim 1 or 2, in which the primary windings embracing the individual subsidiary elements of a main core are connected in series or parallel opposition.

4. A device as claimed in claim 1, in which a primary winding embracing one subsidiary element of each of the two main cores is connected in series with a primary winding embracing the other subsidiary element of each of the two main cores.

5. Improvements in or modifications of the electro-magnetic devices claimed in specification No. 4766/53, substantially as described and as shown in any of the Figures of the accompanying drawings.

MARKS & CLERK.

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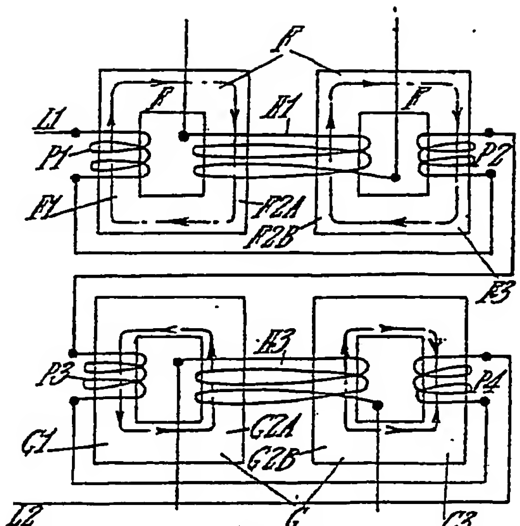

Fig.1.

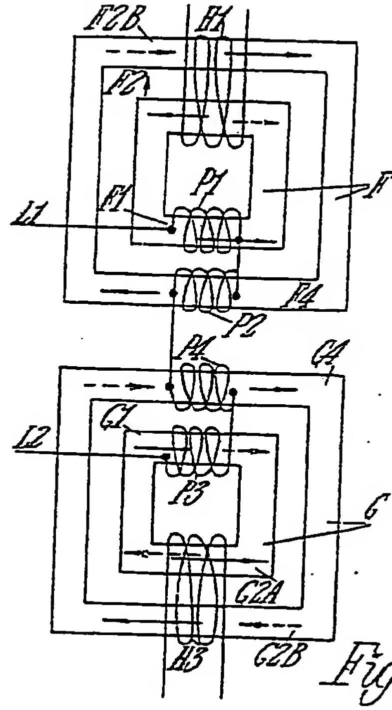

Fig.2.

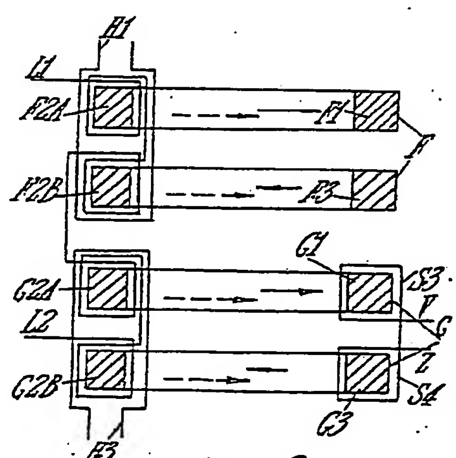

Fig.3.

742,494 COMPLETE SPECIFICATION
2 SHEETS

This drawing is a reproduction of the Original on a reduced scale.
SHEETS 1 & 2

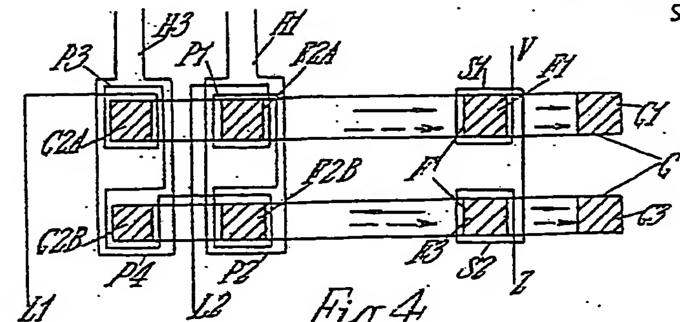

Fig.4.

Fig.2.

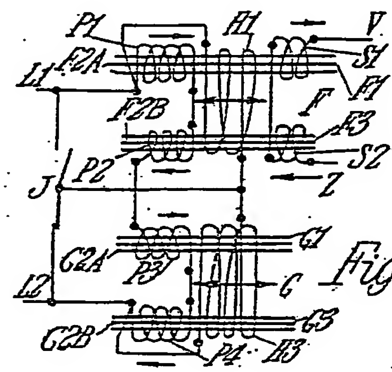

Fig.5.

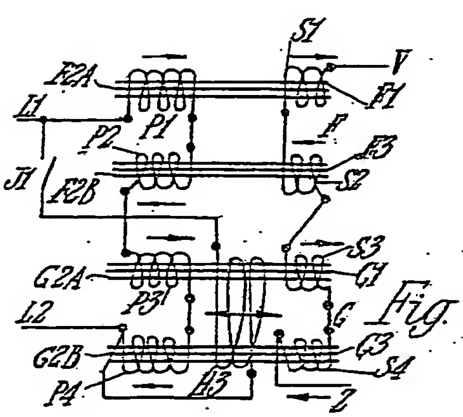

Fig.6.

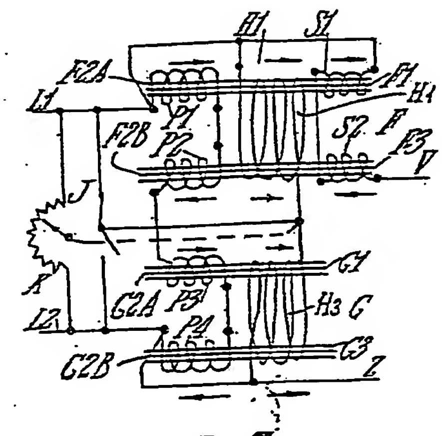

Fig.7.

742,494 COMPLETE SPECIFICATION
2 SHEETS

This drawing is a reproduction of the Original on a reduced scale.
SHEETS 1 & 2

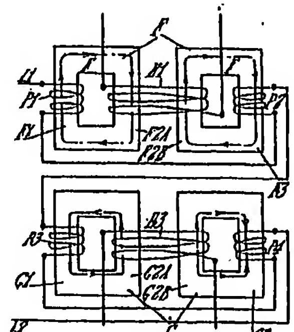

Fig.1.

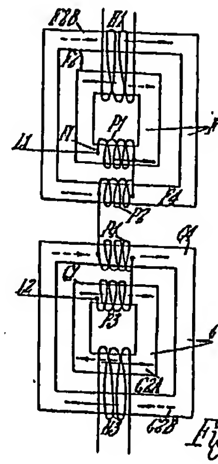

Fig.2.

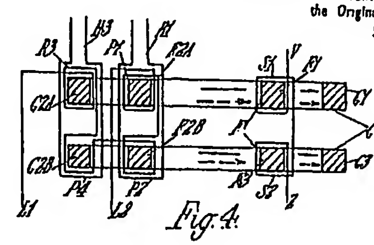

Fig.4.

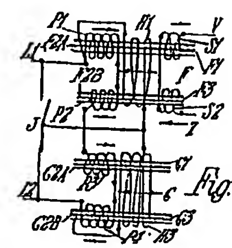

Fig.5.

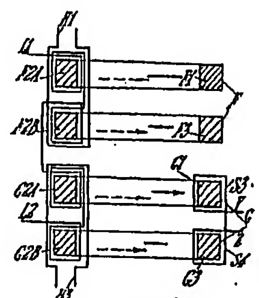

Fig.3.

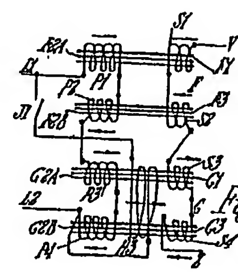

Fig.6.

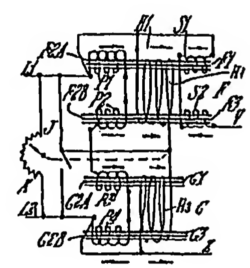

Fig.7.